Economics of Technology Standards: Implications for Offline Movie Piracy in a Global Context

Ramnath K. Chellappa & Shivendu Shivendu
BRI 401, 3670 Trousdale Parkway
Department of IOM, Marshall School of Business
University of Southern California, Los Angeles, CA 90089
ram@marshall.usc.edu & shivendu@usc.edu

Abstract

Reduced sizes of music files due to compression technologies has allowed for piracy to become a rampant problem on the Internet even in the absence of significant bandwidth. However given the large sizes of video files, movies are still largely pirated by duplicating DVDs, VCDs and other physical media. Conventionally DVD formats have differed across various regions in the world albeit for controlling theatrical releases of movies. This paper formulates an analytical model to study the implication of varying technology standards of DVD players across different regions on the piracy of movies. This research identifies conditions under which consumers will engage in global and regional piracy. Our findings show that maintaining separate technology standards across regions is effective in not only thwarting global piracy but it also allows movie studios to create variable quality movies and engage in discriminatory pricing. While consumers may still engage in local piracy, the overall profits to the firm under variable technology standards are shown to be higher when a common DVD standard is adopted across all regions. The paper concludes with recommendations for research and practice.

1. Introduction

As the debate on online music piracy rages, piracy of movies continues in the offline world in the form of illegal copies of Digital Video (also called Versatile) Discs (DVDs) and Video Compact Discs (VCDs). The large size of video files of movies combined with the lack of sufficient Internet bandwidth has stemmed online movie piracy to a limited extent. Even if the general propensity of consumers is to watch videos on television rather than computers, Napster equivalents such as Morpheus, Grokster and Kazaa, have been fuelling online movie piracy as well [1]. However, conversion of movies to online formats such as DivX and asf, not only reduce the visual quality of DVD movies but they also cannot support the interactivity (e.g., scene selection, song selection, etc.) provided in the original DVD movies. Statistics from the Motion Picture Association of America (MPAA-http://www.mpaa.org) also concludes that optical and video piracy around the globe, not just in the US, is the most significant threat to the future of the movie industry.

In the global context, unlike stereo players and audio CDs, for historical and marketing reasons, technologies for moving pictures such as televisions and VCR players (PAL, NTSC, SECAM) and DVD players (Regional Management Information Codes - RMIC) have always employed different standards in various parts of the world. In this paper, we explore the implications of maintaining different global technology standards on a movie studio’s marketing and pricing decisions amidst the threat of piracy. The role of technology standards in creating externality benefits has been well documented in economics and IS literature [2, 3]. Particularly with regards to piracy, it has been argued that while indeed there are losses to a firm, piracy might be beneficial in that it may create demand side externalities [4, 5], although it has also been argued later that piracy losses outweigh such benefits [6]. In fact, later work [7] has shown that some of these benefits from piracy, e.g., sampling can be better abstracted as a proactive vendor strategy. Thus, our research ignores any negligible externality benefits from piracy, and argues that by maintaining different technical standards for DVDs across regions; firms can not only eliminate global piracy, but can also engage in quality segmentation and price discrimination. Interestingly our analysis also reveals that piracy is not a victimless crime, and global piracy may lead to situations where the regions that have a higher marginal willingness to pay stand to lose. Thus it is in the interest of both movie studios and customers from higher income regions such as the US to prevent piracy.

2. Model Development
In order to model piracy in an international context, we not only need to consider the role of technological standards, but also the legal infrastructures that place varying emphasis on copyright enforcement laws, and customers that have varying marginal willingness to pay for quality, and different ethical propensity to pirate. In order to understand these differences, a discussion of quality differentiation in DVDs is warranted. Unlike in online broadcasts where quality differences are primarily based on streaming bandwidth, DVDs can be differentiated based on the number of features that offered along with the movies. For example, movie DVDs are almost always released after studios have extracted the share of revenue from theatrical releases, so a very common way for studios to enhance DVD viewing experience is to provide additional features in the DVD. Primarily these include interview with the stars, uncut footage (sometime called directors’ cut) that could not be shown in theatres, bloopers, and a variety of other material that sometimes makes the DVD a collector’s item. In addition, many DVDs also include technological quality enhancements such as wide-screen viewing, dubbing in a variety of languages, subtitles, and some times even special effects that are not possible in theatres. Such additions to the actual movie shown in theatres are often the main attraction for period pieces and technologically sophisticated movies. For example, the DVD release of the movie Lord of the Rings has special features that include TV footage, documentary shorts, theatrical trailers, a music video by the artist Enya, and video game previews. Thus on a quality or features scale, a simple copy of the theatrical release would be on one end of the scale, while a high quality, more features, enhanced DVD would represent the other end. Enhancing the DVD quality by adding features not only incurs the technological costs of producing anamorphic wide-screen DVDs, but also royalty payments for footage not included in theatres. Thus for modeling purposes we assume that the marginal cost of producing the DVDs is a function of its quality $q$, as given by equation (1):

$$c(q) = a + \frac{q^2}{2} \quad (1)$$

where $a$ is some fixed cost. The quadratic cost function captures the higher infrastructure investments and royalty costs incurred in offering enhanced DVDs. For modeling purposes we consider two regions A and B that are representative of the variations in customer segments, copyright laws and technological standards, and the quality of DVDs produced for these regions is given by $q_A$ and $q_B$, the customer base in each region is given by $N_A$ and $N_B$. Note that we consider only optical and video piracy (offline) for our analysis as our focus is on understanding piracy of movies. Findings of MPAA suggest that movie piracy is predominantly found in the offline context, unlike music and software piracy.

### 2.1 Regional differences in customer segments and copyright enforcements

In the context of software, Gopal and Sanders [8] find that not only does piracy vary across different regions of the world, but it is also related to the GDP of a country and in fact different countries do have different incentives to enact and enforce copyright protection. Along similar lines, in this research we assume that movie piracy also exhibits similar characteristics, e.g., if GDP is representative of the disposable income of customers, regions with higher GDP have will have a higher willingness to pay. For example, in the case of DVDs, customers in regions that include the US and other western countries (region A) can be assumed to possess a higher marginal willingness to pay compared to customers in China and other developing countries (region B). We represent this value as $\theta_A$ and $\theta_B(\theta_A > \theta_B)$ respectively, and the utility derived by the consumers in each region if they buy or pirate a DVD of quality $q$ is given by $\theta_A q$ and $\theta_B q$. Prior research [7, 9] also finds that piracy is related to a consumer’s ethical propensity towards copyright laws, i.e., a consumer with a low moral or ethical predisposition will suffer a smaller moral cost when she chooses to pirate or obtain an illegal copy of a movie. For the purposes of modeling we assume that the consumers in regions A and B suffer moral costs that are given by $\beta_A^h, \beta_A^l$ and $\beta_B^h, \beta_B^l$, where the superscripts $h$ and $l$ represent the high and low bounds of these costs. The proportion of high and low moral customers in each region is given by $\gamma_A, 1-\gamma_A$ and $\gamma_B, 1-\gamma_B$. We also assume that $\beta_A^h > \beta_B^h$ and $\beta_A^l > \beta_B^l$, i.e., the least moral consumer in region A is still more moral than the least moral consumer in region B, and similarly the most moral consumer region B is still less moral than the most moral consumer in region A. We call this the moral bands of region A ($\beta_A^h \leftrightarrow \beta_A^l$) and region B ($\beta_B^h \leftrightarrow \beta_B^l$).

Note that we do not make any assumptions about the width of these bands. Consistent with the observations of Gopal and Sanders [8], we assume that region A (representative of US and other western countries) has strong enforcement mechanisms as compared to region B, such that the punitive costs (a combination of fines...
and expectations of getting caught) suffered by a consumer who pirates in the region is given by $E_A$ and $E_B (E_A > E_B)$ [7].

Figure 1: Regional codes for DVDs

2.2 Regional differences in technology standards for DVDs

<table>
<thead>
<tr>
<th>Factors</th>
<th>Region A (US)</th>
<th>Region B (China)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marginal willingness to pay for quality</td>
<td>$\theta_A$ (High)</td>
<td>$\theta_B$ (Low)</td>
</tr>
<tr>
<td>Moral cost reflective of ethical propensity to pirate (proportion)</td>
<td>$\beta_A, \beta_A^i, \beta_A^p$</td>
<td>$\beta_B, \beta_B^i, \beta_B^p$</td>
</tr>
<tr>
<td>Emphasis on copyright enforcement</td>
<td>$E_A$</td>
<td>$E_B$</td>
</tr>
<tr>
<td>Standards adopted</td>
<td>$S_A$</td>
<td>$S_B$</td>
</tr>
<tr>
<td>No. of consumers</td>
<td>$N_A$</td>
<td>$N_B$</td>
</tr>
</tbody>
</table>

Table 1: Differences in regions A and B

In order to segment our regions across the globe we adopt the division created by the use of RMIC (Regional Management Information Code for DVDs - www.unik.no/~robert/hifi/dvd/world.html) for DVDs that is used by the MPAA member studios and all its allied organizations. Figure 1 shows the six main regions used by DVDs, and in addition codes 7 (Reserved) and 8 (Special international venues - airplanes, cruise ships, etc.) are also used. The main reason movie studios have adopted these regional codes is so that they can control the home release and theater releases of their pictures in different countries (e.g., a picture already on DVD in the US, might just be released in theatres in China). Each DVD player is given a code for the region in which it’s sold and it will not play discs that are not coded for its region. It is not an encryption system, but just one byte of information on the disc that the player checks. However, it is a permanent part of the disc, and will not "unlock" after a period of time. Although regional codes are entirely optional for the producer of a disc, so far almost all Hollywood releases play in only one region. For the two regions we consider in our model, we assume that the standards for regions A and B are given by $S_A$ and $S_B$. A summary of the differences in the regions is given in table 1.

2.3 Pricing in the absence of piracy

We adopt a contract-theoretic setting to model the regional differences discussed above, but before we develop models that include the effect of piracy, we first find optimal prices that a vendor would charge for the DVDs in each region in the absence of any piracy. Without loss of generality, and for simplifying the analytical results we assume $a = 0$ in equation (1). If $p_A$ and $p_B$ represent the prices in regions A and B, the studio’s profit maximization problem can be set up as

$$\max \left[ N_A \left( p_A - \frac{q_A}{2} \right) + N_B \left( p_B - \frac{q_B}{2} \right) \right]$$

subject to the individual rationality (IR) or the participation constraints, given by equation (3).

$$\theta_A q_A - p_A \geq 0 \quad \text{IR}$$

$$\theta_B q_B - p_B \geq 0 \quad \text{IR}$$

Now we consider the optimal solution to this strategy under two distinct cases, when the standards are different across the two regions ($S_A \neq S_B$) and when they are the same ($S_A = S_B$).

Lemma 1: When the DVD standards between two regions are incompatible ($S_A \neq S_B$), it is optimal for the movie studio to create a fully enhanced DVD for region A, given by quality $Q_A^* = \theta_A$ and price
$P_A^* = \theta_A^2$ and a less enhanced movie DVD for region B given by quality $Q_B^* = \theta_B$ and price $P_B^* = \theta_B^2$. The profit is given by $\Pi = \frac{N_A \theta_A^2 + N_B \theta_B^2}{2}$.

When the standards between the two regions are different from each other it implies that one region’s DVD will not function in the other, and hence it allows for the studio to indeed create two vertically differentiated products, and price them differently. From a contract theory viewpoint, this implies that there are no separate incentive compatibility (IC) conditions to be fulfilled, i.e., consumers will only buy DVDs meant for their region and the monopolist will extract full consumer surplus from each region.

**Lemma 2:** When the DVD standards between the two regions are the same ($S_A = S_B$), it is optimal for the movie studio to create an enhanced DVD for region A with the same quality as given in Lemma 1, $Q_A = Q_A^* = \theta_A$, and a lowered price given by

$$P_A = \theta_A^2 - (\theta_A - \theta_B)\left[\theta_B - \frac{N_A}{N_B}(\theta_A - \theta_B)\right].$$

For region B, it is optimal for the vendor to offer a DVD of quality $Q_B = \theta_B - \frac{N_A}{N_B}(\theta_A - \theta_B)$ and price $P_B = \theta_B\left[\theta_B - \frac{N_A}{N_B}(\theta_A - \theta_B)\right]$. The profits are given by $\Pi = \frac{N_A \theta_A^2 + N_B \theta_B^2 - 2N_A \theta_B (\theta_A - \theta_B)}{2(N_A + N_B)}$.

When the technological standards are the same across the two regions, then it may actually be possible that some consumers in region A may choose to buy a product meant for region B. This is a real possibility today over the Internet where geographical boundaries are of no constraint. Interestingly, the publishing industry has also faced such problems, and as a result one finds only hardcover editions of certain books in the US market that are priced higher than their Eastern Economic Editions (paperback, low quality paper) counterpart sold in countries such as India. From the modeling perspective region A ($\theta_A$) will choose contract ($Q_B^*, P_B^*$), as it will provide a strictly positive utility, i.e., $\theta_A q_B - p_B > \theta_B q_B - p_B$ as $\theta_B q_B - p_B = 0$ and $\theta_A > \theta_B$. Thus the price and quality offered in Lemma 1 is not suitable when the standards across the two regions are the same and therefore the studio has design DVDs and price such that the consumer’s incentive compatibility constraints given by equation (4) are satisfied

$$\theta_A q_A - p_A \geq \theta_A q_B - p_B \quad \text{(IC)}$$

$$\theta_B q_B - p_B \geq \theta_B q_A - p_A \quad \text{(IC)}$$

This ensures that even when the standards are the same across the two regions, the customers in region will buy only the DVDs meant for their region.

**Proposition 1:** Even if no threats of piracy exist, it is optimal for the movie studio to maintain different technology standards for the DVDs.

Proposition 1 is fairly obvious when we compare the profits from Lemma 1 and Lemma 2. When standards are common, the DVD produced for region B (at prices meant for region B) will also yield a positive utility for consumers in region A. Hence to ensure that region A will buy only the DVD meant for them, the vendor has to lower the price in region A as compared to the prices in Lemma 1. This is equivalent to the information rent paid in economic formulations of contracts under information asymmetry. In addition, the quality and prices are both lowered for region B when the standards are common. While the profits to the movie studio are always greater when the regional standards are different, and customers of region A stand to gain when the standards are common. Figure 2, shows the relative positions of prices and DVD qualities in both cases.

**Proposition 2:** When the standards are common and no threats of piracy exist, the movie studio will find it
optimal not to serve region B when \( \theta_B \leq \frac{N_A}{N_B} (\theta_A - \theta_B) \).

When there is no fear of piracy and if the marginal willingness to pay for quality is very small in region B, then it may simply be better for the studio to create only the enhanced, high quality DVD for customers of region A. This is because the loss in profit due to lowering of price in region A (to ensure that they don’t buy the DVD meant for region B) is not compensated by the customers in region B. Also as we can see from Lemma 2, the quality provided to region A is the same in both standards situations, but a lower quality is offered for region B when the standards are the same. For practical purposes this lower quality can be the equivalent of a DVD with just the regular movie, while region A’s DVD can represent the fully enhanced DVD with all the features included. In the following sections when we introduce threats from piracy, we assume that the quality has been fixed at this level determined by Lemma 2, i.e.

\[
q_A = Q_A = \theta_A
\]

and \( q_B = Q_B = \theta_B - \frac{N_A}{N_B} (\theta_A - \theta_B) \). This implicitly assumes that the movie studio determines the features in the CD prior to any knowledge of piracy.

3 Role of standards when consumers engage in regional and global piracy

In order to understand the implications of piracy on DVD sales and optimal pricing, we first define two types of piracy, regional and global piracy. Regional piracy occurs when a consumer obtains illegal copies of the DVDs meant for her own region, while global piracy occurs when the consumer pirates the DVD meant for the other region. To model piracy, we adopt the contract-theoretic setup from Chellappa and Shivendu [7], where a consumer’s decision to pirate has been modeled as the equivalent of a consumer being offered extra contracts by Satan (or whoever the reader prefers), tempting the consumer to pirate. Along these lines, we do not consider the consumer to incur any direct monetary cost of pirating, e.g., from searching for pirated copies. We also assume that the pirated version does not suffer in quality or any other attribute as compared to a legitimate copy. Therefore we can represent the price paid by a consumer when she pirates, as \( \beta + E \), e.g., for a consumer in region B with a low morality, the cost of pirating would be given by \( \beta_B + E_B \). Note that in our model the price is deterministic as offered by the movie studio while the price paid by the consumer when she pirates, is a discrete random variable that is determined by her region and her moral type.

3.3 Piracy when standards are common for regions A and B (\( S_A = S_B \))

We conduct this analysis to understand the implications of piracy when regions A and B use the same standards, i.e., what works on a DVD player in region A would also work in region B. As discussed earlier the quality levels (of regular and enhanced DVDs) have been fixed when the vendors designed the digital product without any assumptions of piracy (given in Lemma 2).

**Proposition 3:** When standards are common only the enhanced DVD meant for region A will be pirated in both regions, i.e., both regional and global piracy will involve only the enhanced DVD.

Whenever a consumer pirates, be it a product belonging to her own region or the other, the combined moral and punitive costs she suffers during piracy is the same as can be seen from the construction provided in section 2.1. However, the utility that a consumer of either region gets from pirating is always higher for the enhanced DVD, and hence even region B consumers will always pirate the product of region A. However, the real extent of piracy and the corresponding vendor strategies will depend on the positions of the moral bands given in section 2.1. Thus in the following sections, we provide a case by case analysis of piracy, prices and profits with varying positions of the moral bands.

![Figure 3: Relative positions of moral bands](image)
Proposition 4: The price equivalent cutoff for region B’s consumers to engage in global piracy is given by \( \theta_A^B \theta_B^A \).

Given proposition 1, we can see that the decision to pirate for consumers in region B is not based on a comparison of their moral costs and the \( P_B \), rather they would trade off their moral costs against the potential utility \((\theta_A^B \theta_B^A)\) they would derive from pirating the enhanced DVD from region A (see figure 3). There are two trivial cases, first when \( E_B + \beta_B^A \geq \theta_A \theta_B \) and \( E_A + \beta_A^B \geq P_A \), which implies that no customer in either region will pirate. Second, when \( E_A + \beta_A^B < P_A \) and \( E_B + \beta_B^A < P_B \), which implies that consumers in both regions will pirate. So, for the sake of illustration, we only analyze the more general cases when there is potential for a combination of global and regional piracy to exist, and vendor can vary prices to lessen the loss in profits.

Case 1: When only customers in region B engage in piracy

This section analyzes a case in which the consumers in region A will not engage in piracy as their cost from pirating is higher than the price charged by the studio, i.e., \( E_A + \beta_A^B \geq P_A \). Under this condition we consider various positions of region B’s moral band and their implications on piracy. We first consider the situation where in region B the proportion \( (1 - \gamma_B) \) of consumers with low moral value will engage in piracy, i.e., their utility from pirating the enhanced DVD will be more than their moral cost of pirating. While regional piracy appears to be protected by prices in region B, the availability of enhanced DVDs due to same standards will allow for global piracy by some customers in region B. In some cases, this may even require that the enhanced DVDs be not offered.

Lemma 3: The shutdown condition for region A when \( P_B \leq E_B + \beta_B < \theta_A \theta_B \) and \( E_A + \beta_A^B \geq P_A \) is given by

\[
\theta_B^2 - \left[ \frac{N_A (\theta_A - \theta_B)}{N_B} \right]^2 \left[ N_A + N_B (1 - \gamma_B) \right] > \left[ \theta_A^2 - 2 (\theta_A - \theta_B) \left( \theta_B - \frac{N_A}{N_B} (\theta_A - \theta_B) \right) \right] N_A
\]

Corollary 1: When \( E_B + \beta_B^A < P_B \) and \( E_A + \beta_A^B \geq P_A \) then movie studio will not benefit from shutting down region A.

Consumers of region B defined in Lemma 3 include those who will engage in global piracy, but will not engage in regional piracy even if the enhanced DVD is no more available, as the price of the regular DVD satisfies their utility requirements and pirating the same will yield a negative utility. Since consumers of region A get a positive utility from buying DVD of region B, not producing the enhanced DVD will force both customers of region A and B to buy the regular DVD. The shutdown condition itself is determined by comparing the profits when consumers from both regions buy the regular DVD, with the profits when low moral value customers of region B are allowed to pirate the enhanced DVD when it is offered. A special case of Lemma 3 is when even the high moral types in region B will engage in global piracy and this is equivalent of taking \( \gamma_B = 0 \), in the expression. However, when the low moral types of region B get a positive utility from regional piracy, shutting down A provides no relief, as given in corollary 1. This is because the loss in surplus by shutting down region A is not compensated by any change in pirating behavior of region B’s customers as those who will pirate in region B will continue to pirate region B’s own products. In other words, given an option, pirates in region B will engage in global piracy, but when the enhanced product is not available, they will switch to regional piracy. Note that we assume that pirating only leads to a potential loss in revenue and no production cost is incurred for the pirated units.

Lemma 3 and its corollary reveal that the decision to shutdown region A is a function of the total customer base of both the regions and the proportion of high moral types in region B. It is interesting to note that while the movie studio considered shutting down region B under some conditions when there was no piracy, in the presence of piracy threats it is region A that would be shutdown. This implies that when there is sufficient threat of global piracy, movie studios may not invest in creating enhanced DVDs and thus robbing the customers with high willingness to pay for quality of the chance to watch a superior quality DVD. To the extent that a consumer willing to pay for superior quality should be able to enjoy an enhanced DVD, the notion that piracy is a victimless crime, i.e., that an average consumer does not suffer but rather only the large corporation’s profits are affected, is not true. Thus in countries like the US where many consumers turn a blind eye towards others pirating, e.g., posting DVD decryption codes, would not be beneficial to them in the long run.
Case 2: When only customers in region A engage in piracy
In this situation we assume that the moral costs of region B’s consumers are high while those in region A might be incentivized to pirate.

Lemma 4: When only the low moral type customers in region A will engage in piracy, i.e., \( E_B + \beta_B^i \geq \theta_A \theta_B \) and \( E_A + \beta_A^i < P_A \), it is optimal for the movie studio to revise the prices of the enhanced DVD when \( P_A < \frac{E_A + \beta_A^i - \theta_A^2 (1 - \gamma_A)}{2 \gamma_A} \). The movie studio will need to pay a moral rent of \( \left( P_A - \left( E_A + \beta_A^i \right) \right) \) to the high moral types in region A.

Lemma 4 informs us that in addition to any information rent paid to region A to ensure that they only buy DVDs meant for their region (discussed in proposition 1), due to variations in morality of customers in this region, the movie studio may have to lower its price further. This price incentive has been referred to as the moral rent [7] that is paid to ensure that customers continue to buy and not pirate. This moral rent is similar to the common construct of information rent that is paid when the seller does not have full information about the type of the consumer.

Corollary 2: When all customers in region A will engage in piracy, i.e., \( E_B + \beta_B^i \geq \theta_A \theta_B \), and \( E_A + \beta_A^h < P_A \), the movie studio will be forced to revise its prices or stop offering enhanced DVDs.

Corollary 3: It is optimal for the movie studio to revise the prices of the enhanced DVD if \( \frac{1}{2} \left( \theta_B^2 - \left( \frac{N_A \left( \theta_A - \theta_B \right)}{N_B} \right)^2 \right) < \left( E_A + \beta_A^h - \frac{\theta_A^2}{2} \right) \gamma_A \).

The movie studio will find it optimal to pay a moral rent to at least the high moral types in region A.

Corollary 4: The movie studio will find it optimal to pay a moral rent to all customers in region A if \( E_A + \beta_A^h + \gamma_A \beta_A^h \geq \theta_A^2 \frac{\theta_A^2 (1 - \gamma_A)}{2} \).

If all consumers in region A will pirate if an enhanced DVD is offered, then it may simply be best for the movie studio to only offer the regular DVD in which case the region A consumer might also add to the profits from region B. Therefore, corollary 2 reasons that some action is required on the part of the vendor. Corollary 3 informs us that under some conditions it is actually optimal to revise the prices of the enhanced DVD, so that at least the high moral types in region A might start buying. But if conditions described in corollary 4 are also met, then movie studio may actually be in a position to revise its prices so as to incentivize all customers in region A to buy.

Case 3: When customers in both regions engage in piracy
This is the most general situation when there are some customers in both regions who will engage in piracy. As discussed in case 1, if the enhanced DVD is available, the customers in region B who pirate will necessarily pirate only the enhanced DVD. Hence it suffices to analyze the case when \( E_B + \beta_B^i < \theta_A \theta_B \) and \( \theta_A \theta_B < E_A + \beta_A^i < P_A \). The movie studio cannot provide price incentives in region B to stop global piracy, and hence it has only 3 options, option 1 - persist with the global piracy in region B and local piracy in region A, option 2 - stop offering the enhanced DVD completely to stop global piracy or option 3 - to revise prices of the enhanced DVD similar to case 2 to stop local piracy in region A.

Lemma 5: The movie studio will find it optimal to allow for global and regional piracy to exist if \( \frac{1}{2} \left( \theta_B^2 - \left( \frac{N_A \left( \theta_A - \theta_B \right)}{N_B} \right)^2 \right) > \left( E_A + \beta_A^h - \frac{\theta_A^2}{2} \right) \gamma_A \) and

\[
\theta_B^2 - \left( \frac{N_A \left( \theta_A - \theta_B \right)}{N_B} \right)^2 \left[ N_A + N_B \left( 1 - \gamma_B \right) \right] < \\
\theta_A^2 - 2 \left( \theta_A - \theta_B \right) \left( \theta_B - \frac{N_A}{N_B} \left( \theta_A - \theta_B \right) \right) \gamma_A N_A
\]

Corollary 5: The movie studio will find it optimal to stop offering the enhanced DVD and therefore stop global piracy if

\[
\theta_B^2 - \left( \frac{N_A \left( \theta_A - \theta_B \right)}{N_B} \right)^2 \left[ N_A + N_B \left( 1 - \gamma_B \right) \right] > \\
\theta_A^2 - 2 \left( \theta_A - \theta_B \right) \left( \theta_B - \frac{N_A}{N_B} \left( \theta_A - \theta_B \right) \right) \gamma_A N_A
\]
\[
\frac{N_A + N_B (1 - \gamma_B)}{2} \left( \theta_B^2 - \frac{\left( N_A (\theta_A - \theta_B) / N_B \right)^2}{\theta_B} \right) < \left( E_A + \beta_A - \frac{\theta_A^2}{2} \right) N_A
\]

**Corollary 6:** The movie studio will find it optimal to revise the prices of the enhanced DVD and therefore stop regional piracy if

\[
\frac{1}{2} \left( \theta_B^2 - \frac{\left( N_A (\theta_A - \theta_B) / N_B \right)^2}{\theta_B} \right) < \left( E_A + \beta_A - \frac{\theta_A^2}{2} \right) \gamma_A
\]

and

\[
\frac{N_A + N_B (1 - \gamma_B)}{2} \left( \theta_B^2 - \frac{\left( N_A (\theta_A - \theta_B) / N_B \right)^2}{\theta_B} \right) > \left( E_A + \beta_A - \frac{\theta_A^2}{2} \right) N_A
\]

Lemma 5 and corollaries 5 and 6 are arrived at by comparing the profits under each of the options discussed above. The conditions given in the lemma and corollaries have been derived from the special cases discussed in case 1 and 2. In conclusion, the analysis of the impact of piracy when the standards are common across the two regions provides two important implications. First, people in region B will engage in global piracy that cannot be controlled by price incentives. However, shutting down the enhanced DVD offering does not imply that all piracy will stop as regional piracy by customers in both regions can still continue. A second implication is that regional piracy in region A can be controlled through price incentives but the decision to shutdown or revise prices is a function of the total customer base in region A.

We now analyze the implications to piracy when the movie studio is able to maintain two separate standards for the two regions.

3.4 Piracy when separate standards are employed in regions A and B \((S_A \neq S_B)\)

When the DVD standards are different in the two regions then a DVD sold in one region cannot be operated by a DVD player in the other region, and thus it automatically obviates any global piracy. Hence the pricing decision of the vendor has to only accommodate regional piracy in A and B. As discussed in section 2.3, lemma 1, separate standards also imply that no equivalent of an information rent needs to be paid to region A. Hence the movie studio will evaluate its losses in profit due to piracy with the prices set by lemma 1, i.e., \(P_A^*\) and \(P_B^*\). We consider a general case where there are at least some customers (low moral types) in region A and region B who will prefer to pirate products available in their own region.

**Lemma 6:** The movie studio will find it optimal to revise the prices of its DVD offerings when

\[
P_A^* < \frac{E_A + \beta_A - \theta_A^2 (1 - \gamma_A)}{\gamma_A} \frac{2}{2}\gamma_A
\]

and

\[
P_B^* < \frac{E_B + \beta_B - \theta_B^2 (1 - \gamma_B)}{\gamma_B} \frac{2}{2}\gamma_B
\]

The movie studio will provide a moral rent to the high moral types in both the regions. The moral rent for regions A and B would be \(\theta_A^2 - (E_A + \beta_A)\) and \(\theta_B^2 - (E_B + \beta_B)\).

**Proposition 5:** For all comparable cases of piracy (positions of the moral band), the profit to the studio when the standards are separate is always greater than the profit when the DVD technology standards are the same.

For the sake of brevity, we have not compared the profits with same and separate standards for all positions of the moral band. The losses due to global piracy have been completely eliminated due to separate standards. The strategies and revenues in case of regional piracy are the same in both standards cases. On the other hand due to separate standards there is also no need to pay the equivalent of the information rent to region A. Hence the cumulative effect of the above will ensure that profits are always higher when separate standards are adopted for the two regions.

4 Conclusion

In general research in IS and piracy has only focused on the positive externality benefits of maintaining common standards. Our research deviates from this notion and argues that in the case of global piracy, it may be beneficial for digital product firms such as a movie studio to consciously maintain different incompatible standards across two regions. Thus while the implications of potential externality benefits to users has been studied before, our paper adds another perspective on technology standards to this literature. The theoretical contributions of our research are two fold. First of all it establishes a very simple contract-theoretic framework to study the implications of compatible and incompatible technology standards on digital product pricing. It points out that maintaining different
standards for DVDs across two regions can help in vertical differentiation of the movie market. Second, it distinguishes between global and regional piracy, and by varying the marginal willingness to pay and morality of consumer types in two regions, it sheds light on the differences in dynamics of these two piracy types. This analysis reveals that irrespective of the number of pirates and the nature of the piracy, maintaining different technology standards is always optimal for the movie studio. Furthermore, our results show the price incentives are useful only during regional piracy and global piracy can be stemmed only by employing drastic measures such completely shutting down the production of the high quality enhanced DVDs.

From a managerial perspective, it offers important recommendations to movie studios. Movie studios have used the different regional codes in DVD players mainly to time the theatrical and home release of their movies. Our research extends this scenario and encourages the marketing of two DVD types, namely a regular DVD with just the movie and an enhanced DVD with various features such as interviews with stars, unseen footage, and other technical enhancements. The findings recommend variable pricing for these two DVD types in two markets such as the US and China. Our results also make a strong case for maintaining the incompatible technology standards for the DVDs and their players irrespective of piracy problems. Our analysis also provides a deep understanding of the nature of piracy and who it really affects. First of all, we point out that the loss in revenue from global piracy when a customer from China pirates a DVD meant for the US, is still a loss in the Chinese market and not the US market. This is unlike stealing a physical product where the loss is based on what is stolen rather than what may be potentially purchased. And secondly, we show that piracy is not a really a victimless crime in that due to global piracy by customers in China, high willingness to pay regions such as the US can actually stand to lose out on enhanced DVD quality. This implies the movie studios should educate customers in high GDP countries to understand that both pirating and turning a blind-eye to pirating by others can be harmful in the long run. Such consumer awareness may reduce the potential for DVD cracking codes such as DeCSS to be created in western countries, and consumers may even engage in active protection of any intellectual property they own.

4.1 Future research

Our research has fixed the quality levels exogenously as determined by the seller prior to any expectations of piracy. While realistic in current day production of DVDs, it may be interesting to vary quality. This would allow strategies to be formulated at the production stage itself, rather than relying only on pricing strategies during marketing. Further our research has not explicitly considered potential positive externality benefits of pirating, i.e., more piracy can imply greater buzz for the movie and hence potentially a larger legitimate user base. Future research can also include the role of sampling in mitigating piracy losses.

An interesting analytical extension to our model can be to explore the sensitivity of price and profits to changes in the moral cost to a consumer and variations in deterrence cost. For example, we could look at the implications for price once a new copyright protection law is enacted. Further research is required to develop scales and measures for empirical validation of constructs presented here.

5 References
